



Materials Engineering Branch

TIP*



No. 121 Chemical Corrosion of Aluminum by Cleaning Solvents

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An Alert describes a mechanism for the chemical corrosion of aluminum, aluminum wires and aluminum bond pads employed in electronic parts and components involving a combination of water and 1,1,1-trichloroethane (TCE) cleaning solvents¹. As these solvents are among the more popular ones used for cleaning space flight hardware, the information contained in the alert is summarized below to provide guidance in their use.

TCE is an organic solvent commonly used to clean electronic parts and components. However, TCE has a tendency to decompose, producing hydrogen chloride (HCl) as one of the products of decomposition. To prevent this, a chemical additive or "inhibitor" is added to the TCE. The function of the inhibitor is to suppress the chemical decomposition reaction and render the TCE chemically stable for use as a cleaning solvent. A typical inhibitor is 1,4-dioxane and is present in the TCE at a concentration of about 3-wt %.

On occasion, corrosion of metallic components in electronic parts, such as aluminum, is encountered and chemical analysis typically finds chlorine at the corrosion sites. TCE always becomes suspect if it was used as a cleaning solvent. However, efforts to actually corrode metallic components of electronic parts in JPL's failure analysis group, using inhibited TCE, historically have been unsuccessful.

Recently, it was learned that inhibitors such as 1, 4-dioxane are readily soluble in water. Moreover, water and TCE are immiscible; they will not mix. In a laboratory experiment combining water and TCE in a common glass vessel, it was discovered that the 1, 4-dioxane inhibitor can be readily extracted from the TCE, preferring to be dissolved in water rather than TCE. This leaves the TCE without an inhibitor and thus begins decomposition to produce HCl. HCl then dissolves in water, producing hydrochloric acid, which actually causes the metallic corrosion.

Thus, it was found that combining inhibited TCE and water could cause aluminum corrosion, leaving chlorine as a residue at the corrosion sites. Neither inhibited TCE nor water, when used separately, causes this same corrosive behavior. This work was carried out during an investigation of internal corrosion of aluminum wires and bond pads on a 1K memory RAM.

¹ Safe-Alert No. E4-A-89-02, May 10, 1989, E.F. Cuddihy, Jet Propulsion Laboratory.

A peculiarity of this part was the existence of a hole in the lid, permitting contaminants and/or cleaning solvents to enter. The hole was discovered during a hermeticity test. A review of what solvents were used on this failed part revealed that both inhibited TCE and water were employed. In a laboratory test, a de-lidded 1K memory RAM, used as a control, was immersed in the water phase of the combination water/inhibited TCE and heated overnight at the boiling point of TCE (74°C).

On inspection, it was found that the aluminum wires and bond pads were severely corroded, several of the aluminum wires were totally missing, and chlorine was chemically detected at the corrosion sites. Visual comparison of the corrosive damage on the control part was strikingly similar to the corrosive damage on the failed part.

This effort does not conclusively prove that the corrosion of this part was caused by the combination of water and inhibited TCE, but it is strongly indicated. The effort does prove that the seemingly innocent combination of water and inhibited TCE can cause corrosion of aluminum (and perhaps other metals) used in electronic parts and a caution for future use is strongly advised.

Do not mix water and TCE! Use them separately on electronic parts and components and take care that the parts and components are dry of one before using the other. This also applies to alcohols as they generally contain some water.

NOTE: 1,1,1-trichloroethane, which is also known as methyl chloroform is considered an ozone depleting chemical by the Montreal Protocol. As such, it has the potential for severe restrictions on its production and use. It also has severe limitations imposed, in its use in the workplace, by both state and federal agencies.